Smart Technology:
Pathway to Efficient Turf and Landscape Irrigation

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Introduction

- The development of Smart Water Application Technologies™ or SWAT™ was initiated by water purveyors and Irrigation Association.

- "SMART" as defined by Irrigation Association is an irrigation system that functions without human intervention over the life cycle of the crop. It is true there are many SMART products available in the marketplace.

SWAT History

- Water Purveyors and Irrigation Industry met to discuss how to improve water use efficiency
  - ✓ Improve utilization of water saving technology by homeowners
    1. Must be simple/hands-off technology
    2. Cost effective
  - ✓ Encourage adoption through
    1. Incentives/rebates
    2. Education

SWAT Program
Smart Water Applied Technology

- Water Purveyors recognized opportunity to save 30% or more of applied water in turfgrass and landscape irrigation
  - ✓ May be the single largest source of “new” water

Examples of water lost due to run-off and deep percolation from over irrigation.

SWAT

- Need to identify water technology equipment that provides for "significant" water savings in landscape and turfgrass irrigation

Initial program focused on

- ✓ Climate Based Irrigation Controllers
- ✓ Soil Moisture Sensors

SWAT Game Plan

- Target outcomes
  - ✓ Measurable reduction in applied water
  - ✓ Reduce/eliminate organic pesticide run-off
  - ✓ Improve adoption rate and use of appropriate technologies
  - ✓ "Hands-off" controller requirement for homeowners

Purveyor/IA Meeting

SWAT Game Plan

- Irrigation Industry/Water Purveyor Teamed together to meet goals- Facilitated by the Irrigation Association
  - ✓ SWAT Marketing Committee established and currently meets monthly to facilitate the adoption of new technologies
  - ✓ SWAT Technical Committee established to developed testing protocols for irrigation equipment

SWAT Game Plan

- Develop Testing Protocols -Available on IA Website
  - ✓ Controller protocol developed (version 8 under review)
  - ✓ Soil moisture protocol developed
  - ✓ Specifics can be found at "Irrigation.org"
  - ✓ Controller protocol testing currently underway at CIT & 15 or so manufacturers have been evaluated
  - ✓ Soil moisture protocol testing is underway

SWAT Game Plan

- National Agenda
  - ✓ Irrigation Industry/Water Purveyor group working to design Market Transformation strategy for new technologies
  - ✓ EPA has proposed a national ‘Water Sense’ program similar to ‘Energy Star’
  - ✓ EPA has tentatively agreed to accept SWAT protocols

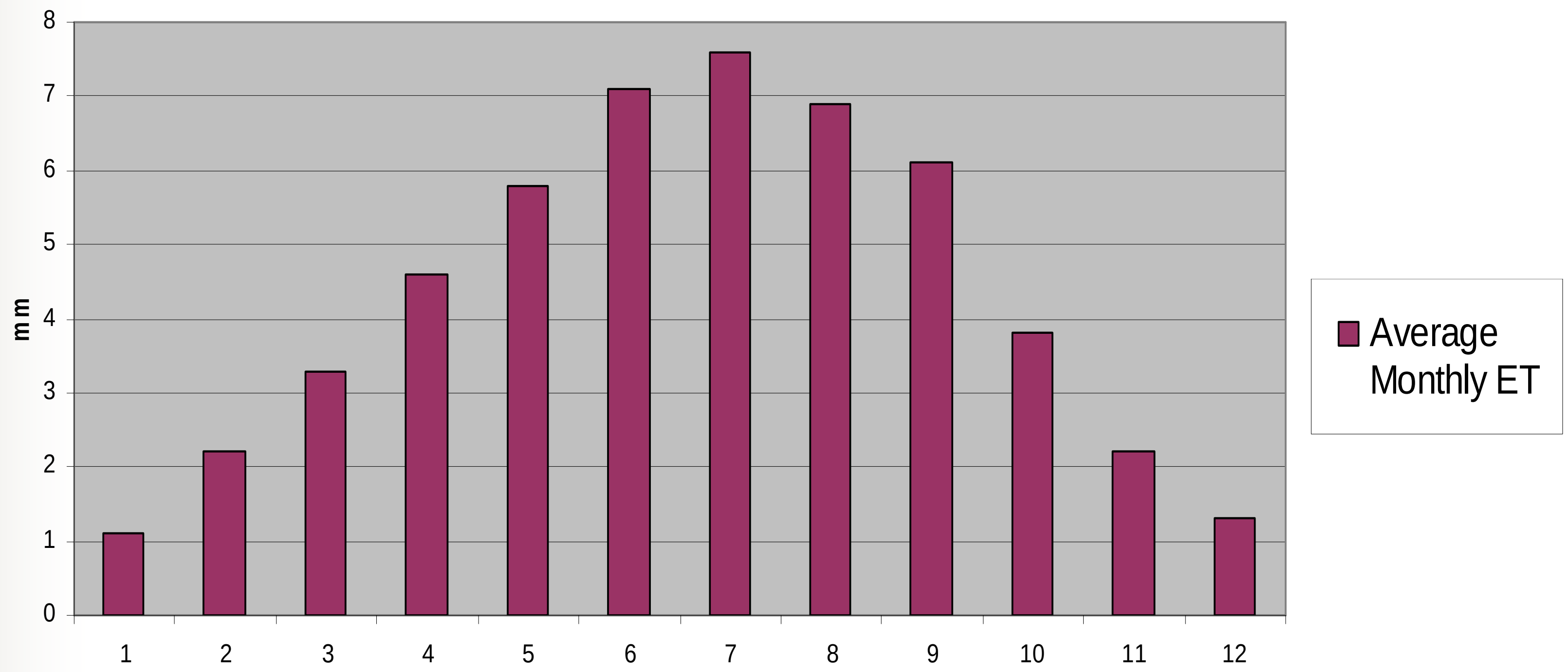
SWAT Game Plan

- **Water Purveyors Begin to Implement SWAT**
  - ✓ Water Purveyors are providing incentives for using SWAT controllers and soil moisture sensors
  - ✓ Regional workshops and seminars are being held to ***"get the message out"***
  - ✓ California's AB2717 Task Force has recommended that all new controllers sold in the State meet the IA's protocol on Climate Based Irrigation Controllers

Commercial Examples of Smart Controllers

1) **Controllers that store historical Etc data**
2) Controllers that utilize an on-site sensor as the basis for calculating real time Etc
3) Controllers that utilize a central weather station as a basis for Etc calculations and transmit the data to individual homeowners from remote sites
4) Controllers that utilize rainfall and temperature sensors
5) Control technology that is added on to existing time-base controllers

Example of Historic ET Data



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On Site ET System

- Generates local site ET from its own dedicated sensors

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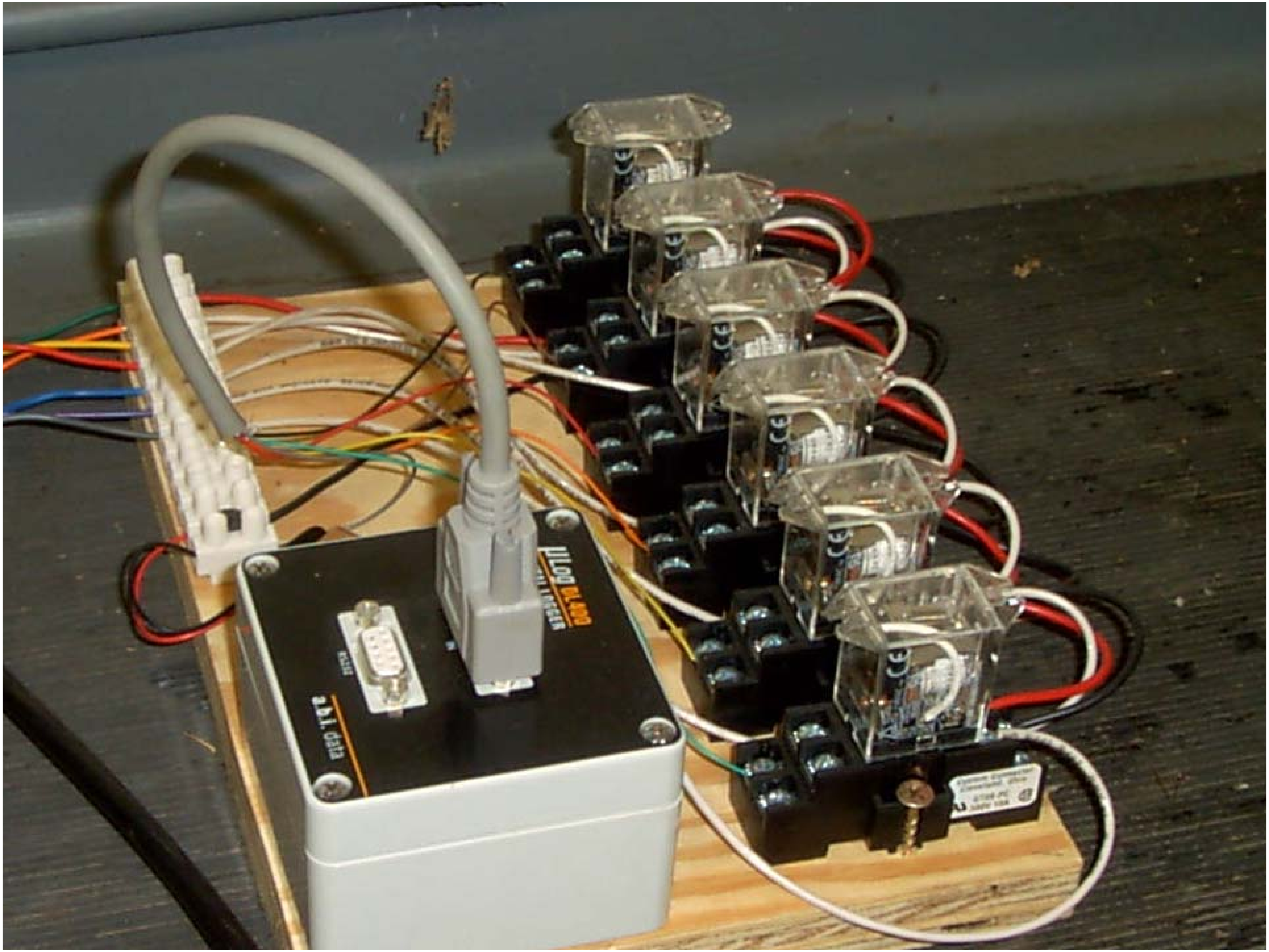
SWAT Game Plan

Target Outcomes

- 20-30% reduction in applied water
- Reduce/eliminate organic pesticide run-off
- Improve adoption rate and use of appropriate technologies

Controller Testing Using the *Irrigation Association's* Testing Protocol



Six Virtual Zones

- High and low precipitation rates
- Tight soils
- Varying slopes
- Drip/micro irrigation
- Sprays and rotors
- Turfgrass, shrubs and trees
- Various micro-climates

Soil Moisture Sensors

Examples of Fundamental Principles

- Electrical conductivity (EC)
- Time domain reflectometry (TDR)
- Heat dissipation

Standardized Testing Protocol

- Following extensive review and revisions by industry personnel, academics and water purveyors, a **"Soil Moisture Protocol 4th Draft"** is available for application on commercially available moisture sensors.

http://www.irrigation.org/swat/industry/draft_protocols.asp

Oven Dried soil being weighed.

Example of Sensor and datalogger

Wetting of the soil box

Soil boxes being weighed

Soil boxes in environmental chamber

Downloading data

Test Methods

Sub-Clause	Subject of Test	No. of tests	Days
6.2.1	Calibration in a fine textured soil with 0dS/m water	3	45
6.2.2	Calibration in a medium textured soil with 0dS/m water	3	30
6.2.3	Calibration in a coarse textured soil with 0dS/m water	3	20
6.3.1	Calibration at 20°C with 0dS/m water	2	35
6.3.2	Calibration at 30°C with 0dS/m water	2	30
6.3.3	Test for freezing susceptibility with 0dS/m water	2	70
6.4.1	Calibration when wetted with water with a conductivity of 1.0 dS/m on a medium textured soil	2	32
6.4.2	Calibration when wetted with water with a conductivity of 1.5 dS/m on a medium textured soil	2	30
6.4.3	Calibration when wetted with water with a conductivity of 3.0 dS/m on a medium textured soil	2	40
6.5.1	Calibration when wetted with water with a conductivity of 1.5 dS/m on a fine textured soil	2	45
6.5.2	Calibration when wetted with water with a conductivity of 1.5 dS/m on a coarse textured soil	2	25

Table 1: Summary of number of days needed to complete tests outlined in SWAT 4th Draft Testing Protocol.

Summary Output

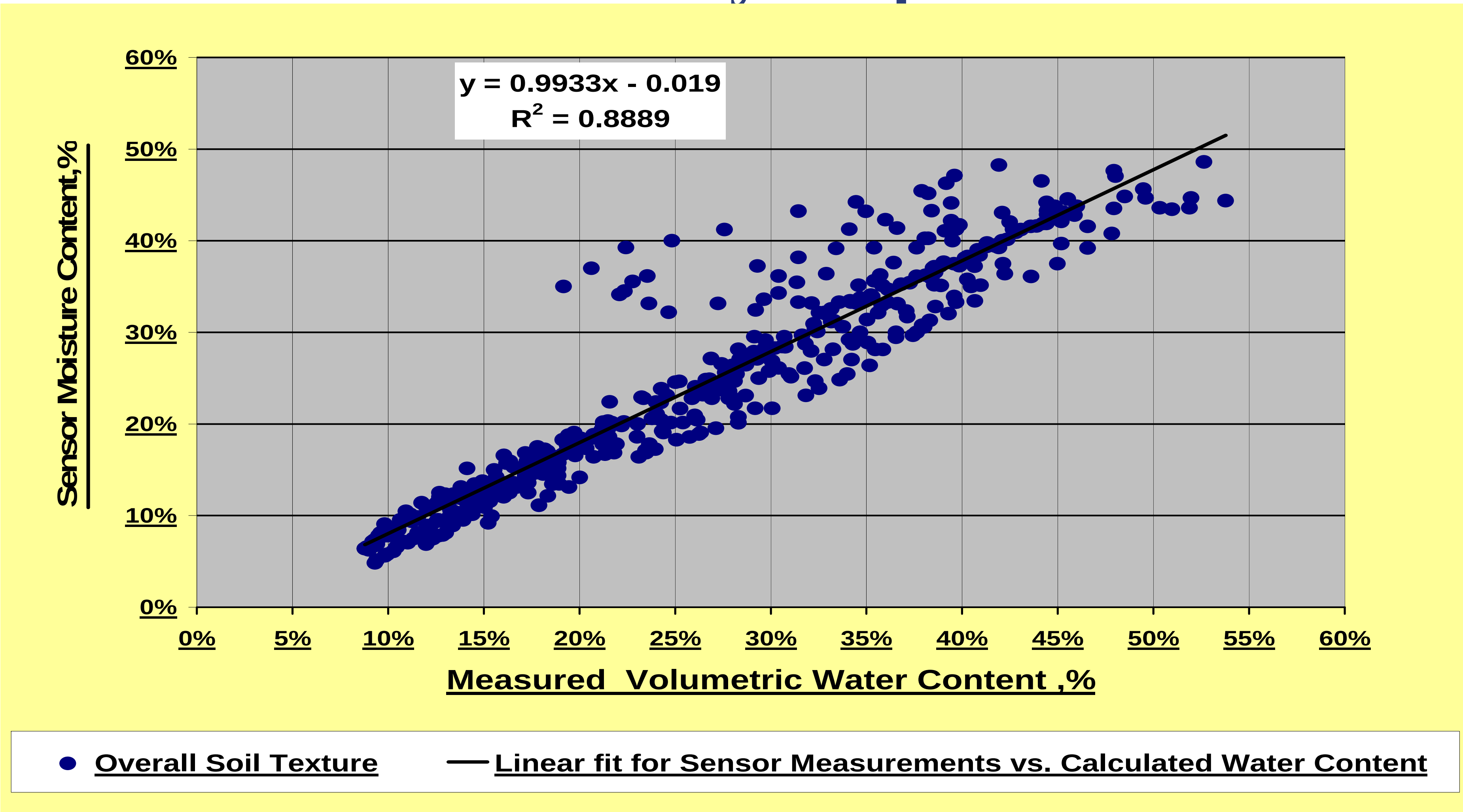


Figure 1: Relationship between volumetric water contents measured with a **Time Domain Transmissivity (TDT)** based soil moisture sensor (Y-axis) and that calculated using the gravimetric water content and bulk density of the soil (X-axis) for Fine, Medium and Coarse Textured soils

IRRIGATION ASSOCIATION
6540 Arlington Boulevard
Falls Church, VA 22042
Tel: 703-536-7080
www.irrigation.org

Smart Water Application Technologies/SWAT Calibration Report

Testing Agency: Center for Irrigation Technology http://cati.csufresno.edu/cit/

Testing Period: July 2007 to October 2008

Product Type: Soil Moisture Sensor

Product Make and Model: Decagon ECH2O EC-5 Soil Moisture Sensor

Product Description: Sensor measures soil volumetric water content

SWAT Protocol*: Turf and Landscape Irrigation Equipment - SOIL MOISTURE SENSORS
Phase 1: Indoor Lab Screening Tests - 4th Draft Testing Protocol

The concept of soil moisture sensors has an extensive history of scientific study and documentation. The objective of Phase 1 lab tests is to determine sensor calibration curves over a range of conditions that affect soil moisture, including soil type, temperature and salinity. Phase 1 testing determines sensor response over manufacturer specified test ranges to continue into Phase 2. At that time the soil sensor will be integrated with an irrigation controller to measure irrigation adequacy and efficiency in a virtual landscape using the current performance criteria of 0.40 inches of rainfall and 2.50 inches of ETo.

Phase 1 Soil Moisture Sensor testing does not test the efficacy of a sensor over the entire range of soil moisture conditions possible and does not measure the integration of a soil sensor with a controller to manage irrigation.

Sensor performance curves were developed to determine the relationship between sensor readings and soil moisture content for a soil filled container. Relationships are determined for a range of soil textures, ambient temperatures and water conductivity values.

*All SWAT protocols may be viewed at www.irrigation.org

Phase 1 SWAT Calibration Summary: Decagon ECH2O EC-5 Soil Moisture Sensor

Measures are between field capacity (i.e. practical soil water holding capacity) and a selected drying range specified by the manufacturer over which the sensor was tested.	Functions
Test of Soil Moisture Sensor	**Response Function Developed[1]**
Response in Fine-Textured Soil	Linear ($Y = 0.7499X + 0.1538$)
Response in Medium-Textured Soil	Linear ($Y = 0.9367X + 0.0665$)
Response in Coarse-Textured Soil	Linear ($Y = 0.9622X + 0.0469$)
Response in Soil at 20 °C (68 °F)	Linear ($Y = 0.8238X + 0.0646$)
Response in Soil at 30 °C (86 °F)	Linear ($Y = 0.9824X + 0.0441$)
Response in Soil Susceptible to Freezing	Linear ($Y = 0.721X + 0.0793$)
Response in Fine-Textured Soil to Irrigation with 1.5 dS/m salinity water	Linear ($Y = 0.8343X + 0.1498$)
Response in Medium-Textured Soil to Irrigation with 1.5 dS/m salinity water	Linear ($Y = 0.7243X + 0.0400$)
Response in Medium-Textured Soil to Irrigation with 3.0 dS/m salinity water	Linear ($Y = 0.6452X + 0.0676$)
Response in Coarse-Textured Soil to Irrigation with 1.5 dS/m salinity water	Linear ($Y = 1.047X + 0.0103$)

[1]Regression equations of the data gathered vs. moisture content as measured by gravimetric sampling, or the measured weight of water in the soil samples. The dynamics of variable manufacture selected calibration endpoints preclude the applicability of correlation coefficients for inter-test or inter-sensor comparisons. A Nonlinear designation means a regression equation other than a straight line was used to best describe the relationship.

Product Detail Supplied by Manufacturer

Decagon ECH2O EC-5 **www.fertileearth.com**

Operation	Features	Additional Hardware
Digital Absolute-reading soil moisture sensor device	❑ Measures dielectric constant. Stable readings regardless of soil conditions ❑ Small profile facilitates use for a broad range of irrigation applications ❑ Ability to act as a moisture transducer in a closed-loop irrigation system ❑ Can measure soil and irrigation system properties for auto-control system setup ❑ No post-install adjustments needed.	**Automatic control equipment** ❑ Fertile Earth ProMeter (available from MorpH2O): Versatile suspended cycle and cycle interrupt add on device. ❑ Compatible with all 24 volt solenoids ❑ Compatible with irrigation clocks that output 24 volts to control solenoids ❑ Integrates at the decoder stage of 2-wire systems

Conclusions

- From the experiments conducted to date, most correlation equations for medium and coarse textured soils were obtained using a liner equation.
- In some cases, fine textured soil a polynomial equation was obtained for best results.
- Data reported for the three classes of soils with emphasis on Field capacity (FC) and Wilting point (WP) in order to determine what should be reported on the IA website.
- The **(Phase2) virtual yard**-protocol beta test is being prepared for testing.

Future SWAT Topics

1) **Overhead irrigation technologies (e.g. sprinklers, sprayers, nozzles)**
2) Low volume irrigation technologies (e.g. emitters, distribution systems)
3) Hydraulic management devices (e.g. pressure control, check valves)
4) Malfunction abatement technologies (e.g. high-flow shut offs, self-cleaning filters)

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Desired Outcome
SWAT Approved Systems

- SWAT equipment
- SWAT design
- SWAT installation
- SWAT operation
- SWAT maintenance


WATER & ENERGY TECHNOLOGY INCUBATOR


Questions ?
Thank You !